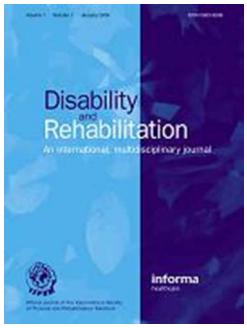

Influence of trunk control and lower extremity impairments on gait capacity in children with cerebral palsy

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Manuscript Title: Influence of trunk control and lower extremity impairments on gait capacity in children with cerebral palsy

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Abstract

Purpose: We investigated the combined impact of trunk control and lower extremities impairments on predicting gait capacity in children with cerebral palsy and evaluated relationships between trunk control and lower extremities impairments.

Method: Data of 52 children with cerebral palsy [29 boys, mean age 11 years 9 months (± 4 years 6 months) were included in this observational study. Gait capacity was measured by the "modified Time Up and Go test". Experienced therapists performed the "Modified Ashworth Scale," "Manual Muscle Test", the "Selective Control Assessment of the Lower Extremity", and the "Trunk Control Measurement Scale". We calculated Spearman correlations coefficients (ρ) and performed regression analyses.

Results: Trunk control was the strongest predictor ($\beta = -0.624$, $p<0.001$) when explaining the variance of gait capacity and remained in the model together with spasticity (R2= 0.67). Muscle strength and selectivity correlated moderately to strongly with the trunk control and gait capacity ($-0.68 \leq \rho \leq -0.78$), but correlations for the spasticity were low ($\rho < -0.3$).

Conclusion: The interconnection between trunk control, leg muscle strength and selectivity for gait capacity in children with cerebral palsy was shown. It indicates the significance of these impairments in gait assessment and, potentially, rehabilitation.

Keywords: spasticity, muscle strength, selective voluntary motor control, regression analysis

Running head: predicting gait via trunk and leg impairments

Article category: original research article, observational study

Words: 3308

Main Text

Introduction

Gait rehabilitation is one of the primary goals within neuro-rehabilitation. The benefits of walking regarding daily mobility and general health-related issues (e.g. bone density and cardiovascular health) are well known for instance for children with cerebral palsy (CP) [1,2]. As the lower extremities and the trunk are involved during walking, knowledge about their individual and combined impact on gait is essential for developing optimal gait-training-strategies [3]. Studies exploring the impact of different lower extremity impairments such as spasticity, contractures, muscle weakness, selective voluntary motor control (SVMC)) on functional ambulation and gross motor function in children with CP found that a lack of muscle strength and SVMC were the strongest predictors [4-11]. Spasticity and a decreased range of motion (contractures) of the lower extremities were found to have smaller effect on gait [5,8,10]. However generalization of these studies results is limited due to their methodological heterogeneity.

Traditionally, disturbed motor control and lower extremity impairments were seen as the primary and secondary gait deviations, respectively [1]. Abnormality of trunk kinematics during walking was mostly considered as a compensatory gait deviation. Recently, this focus has been amended by an increasing number of studies investigating the trunk and upper limbs during walking [3,12,13]. This shift in focus coincided with the development of new trunk control measures for children with CP [13,14]. The first studies in this field provide increasing evidence that altered trunk control during gait in children with CP should not be considered solely as a compensation for gait deviation (due to altered lower extremity functioning), but should also be considered a direct aspect of gait deviation [3,12]. Additional papers concluded that interventions aiming to improve gross motor function in children with CP should also incorporate trunk control training [15,16,17].

However, until now, studies of ambulatory function have investigated the contribution of either lower extremity impairments [4-11] or that of trunk control [3,12,13], with no study assessing both lower extremity impairments and trunk control and evaluating their influence on gait.

Accordingly, the primary aim of this study was to investigate the impact of both lower extremity and trunk control impairments on gait capacity. Based on previous studies [4,8,9,11] we hypothesized that i) negative, moderate (correlation coefficient >.5) relationships exist between gait capacity and lower extremity muscle strength, SVMC and trunk control and ii) a positive, weak (correlation coefficient <.5) relationship exists between gait capacity and lower extremity spasticity. Furthermore, we expected leg muscle strength and trunk control to be the strongest predictors for gait capacity.

In addition, we were interested in investigating how different lower extremity impairments are related to trunk control. Although knowledge about the interdependence between leg and trunk impairments is currently lacking we speculated, based on clinical reasoning, that positive, moderate correlations would be apparent between muscle strength and SVMC with trunk control and also that a negative, weak relationship between spasticity and trunk control would exist.

Method

Participants

In- and out-patients of the "Rehabilitation Centre Affoltern am Albis, University Children's Hospital Zurich" were recruited by convenient sampling. Inclusion criteria were: diagnosis of spastic CP, age between 5 and 20 years, ability to walk (Gross Motor Function Classification (GMFCS) level I-IV), and ability to follow simple instructions. Participants with additional movement disorders, with an unstable situation regarding their tonus-regulating medications and/or who had a botulinum toxin injection within the last 6 months or any surgical correction within the last year were excluded. The study was approved by the ethical committee of the Canton of Zurich (KEK-ZH-Nr.2011-0404). Informed consent and assent were obtained from parents and participants (respectively).

Measurements

All tests were carried out by the same two experienced neuro-pediatric physiotherapists within a maximum timeframe of 1h and in accordance to standardized procedures.

Lower extremity assessments

Spasticity and muscle weakness of hip, knee and ankle flexion and extension movements were assessed with the "Modified Ashworth Scale (MAS)," and the "Manual Muscle Test" (MMT), respectively.

The MAS [18] scores spasticity on an ordinal scale ranging from "0" to "4" in accordance to the velocity dependent definition of spasticity from Katz et al. [19]. Although its criterion validity was established by using the pendulum test [20], its correlation with an increased alpha-motor-neuron activation [21] as well as with increased muscle activation and resistance [22] ranged from weak to moderate only. In children with CP, interrater-reliability of the MAS for the lower extremity joints ranged from weak to good [22,23].

Muscle strength was evaluated with the MMT in accordance to [24]. Scores ranged from 0 – 5. Its scoring system was originally developed and tested on validity for determining muscle weakness in patients with poliomyelitis [25]. Its interrater-reliability has not yet been tested in children with CP, but was moderate to good for children with muscular dystrophy [26]. Although evaluation of the psychometric properties for the MAS and MMT in children with CP is limited, we decided to perform them, as they are considered the clinical standard, and have also been used in previous studies, hence allow comparison of our results [5,8-11].

The "Selective Control Assessment of the Lower Extremity" (SCALE) assesses SVMC at the hip, knee, ankle, subtalar and toe joints and was specifically developed for children with CP. To evaluate the level of SVMC, the child is asked to perform specific and timed isolated movement patterns at each joint. Each joint movement is scored on a three point ordinal scale ranging from 0 – 2 (normal, impaired, unable). Its validity has been established by demonstrating strong correlations (Spearman's $\rho > 0.8$) with the Gross Motor Functioning Classification System (GMFCS) [27,28] and the Fugl-Meyer Test (items III-IV) [28] in children with spastic CP.

Furthermore, a high level of interrater-reliability was demonstrated in this patient group (intraclass correlation coefficient (ICC) above 0.8) [27,28].

Trunk control assessment

Trunk control was assessed using the "Trunk Control Measurement Scale" (TCMS). This is a 15-item assessment that examines sitting balance during functional activities [14]. The TCMS takes into account that the trunk should provide a stable base of support and is also an actively moving body segment. The first five items test static sitting balance followed by ten items testing dynamic sitting balance. Dynamic sitting balance is further divided into two subscales, seven items testing 'selective movement control' and three items testing 'dynamic reaching'. Its validity was supported for children with spastic CP by i) moderate to strong correlations with the "Gross Motor Function Measure" (GMFM) [14,29] ii) significant differences between healthy children and children with CP [14] and iii) a strong correlation with center of pressure measures whilst sitting [29]. Its interrater-reliability was established as the ICC was 0.91 [14].

Gait capacity assessment

For assessing the participants' gait capacity, the modified pediatric version of the "modified Time Up and Go test" (mTUG) [30] was performed. It records the time a child needs to stand up from a chair with foot contact, to walk three meter to a target, turn around and return to the chair and sit down. We performed two mTUG trials and calculated the average time needed. Reliability and validity of the mTUG was supported by a study in a sample of 176 children without physical disabilities and 41 young people with physical disabilities due to CP or spina bifida [30]. In our study, we performed the mTUG twice and included the average time of the two trials in our analyses.

Statistical Analysis

Statistical analysis was performed with SPSS 17.0 (IBM, Armonk, USA). Alpha was set at 0.05 (two-tailed). The Shapiro-Wilk-test showed that the data of most scores were not normally distributed. Hence Spearman's correlation coefficients (ρ) were calculated between the mTUG, age, MMT, SCALE, MAS and TCMS total and sub-scores. We also calculated ρ between the TCMS total and sub-scores and the MMT, SCALE and MAS scores.

In a second step, simple and multiple linear regression analysis (backward modelling) were carried out to determine the most important predictor(s) for explaining mTUG variance. A model using MMT, SCALE, MAS and TCMS total scores as independent variables was analyzed. For the regression analysis, the following assumptions were checked i) homogeneity of variance via a nonsignificant Levin's test; ii) lack of multicollinearity, by calculating the tolerance and variance inflation factor for each independent variable; iii) lack of autocorrelation, by calculating the Durbin-Watson test, and iii) a lack of outliers (case-wise diagnostic) based on the values of Cook`s and Mahalanobis' distance [31,32].

Results

Sixty-eight children with spastic CP gave informed consent for participation. Due to a lack of compliance (lack of motivation, concentration problems) or due to organizational issues (unavailable walking aids) data sets of 14 participants were incomplete. As case-wise diagnostic for the regression analysis revealed that mTUG scores of two participants (GMFCS level IV) laid three standard deviations above the mean, these participants were classed as outliers and omitted from the analyses. Therefore, demographic and performance characteristics of 52 participants are presented in table 1. The 23 females and 29 males were on average 11 years and 9 months (SD 4 years 6 months) old. Twenty-two children had a GMFCS level I, 12 had level II, 16 level III and two level IV. Further clinical characteristics are presented in table 1.

Please insert table 1 about here

Correlation analysis

Correlation results for the lower extremity impairments, TCMS, and mTUG are summarized in Table 2. The MMT total scores showed the strongest relationship with both the mTUG and TCMS total score, closely followed by the correlations between the total SCALE scores and the mTUG and TCMS total score. Lowest correlations were found between the MAS total scores and the mTUG or TCMS total score and its sub-scores. Only the correlation between age and gait capacity was weak and non-significant. Corresponding scatter plots are shown in Figure 1. Furthermore, MMT and SCALE correlated strongly (Table 2).

Please insert table 2 and figure 1 about here

Simple and multiple linear regression analysis

When applying simple linear regression modelling to predict gait capacity, the TCMS total score alone explained most of the variance (54%) of the mTUG, followed by the SCALE (43%), the MMT (40%), and the MAS (31%). As age was not correlated with the mTUG, it was not included in the regression analysis (table 3).

We applied a multiple backward regression model to investigate which lower extremity and/or trunk impairments explain the greatest amount of variance in gait capacity. In the first step the total SCALE score was removed from the model, followed by the MMT score. The TCMS was the strongest predictor with a standardized regression coefficient "β" of -0.624 ($p<0.001$), when explaining the variance in mTUG. Together with the MAS the TCMS remained in the final model and both explained overall 67% of the mTUG variance. To improve the interpretation of these findings, this analysis showed that a decrease of trunk control in the amount of 12 TCMS points resulted in a 6.6 seconds increase of the mTUG.

Please insert table 3 about here

Discussion

The current study showed that trunk control appears to be the strongest predictor for gait capacity, in children with CP and that leg muscle strength and SVMC are strongly related to trunk control in this group.

Prediction of gait capacity

Until now, no study has investigated the impact of both lower extremity impairments and trunk control on gait capacity. While we expected that trunk control and leg muscle strength were the strongest predictors for gait capacity, the MMT, to our surprise, and the SCALE scores were excluded from the regression model. The unanticipated exclusion of the MMT, as well as the exclusion of the SCALE, is likely to be caused by multicollinearity between TCMS, MMT, and SCALE. As multicollinearity is a methodological limitation of our study, its cause and consequences will be explained in further detail in the section below.

The results of our simple regression analysis are in agreement with those of previous studies, which reported the importance of SVMC [4,6-8] and strength [6-8], and a minor influence of spasticity, on gait capacity/performance [6-8].

Nevertheless, a direct comparison regarding the absolute strength of the relationship, between our study and previously published research, is not appropriate due to the existence of several methodological differences: i) previous studies used different dependent variables such as three dimensional gait analysis [10], or gross-motor function [5,9,11], ii) differences in assessments/methods were used to quantify lower extremity impairments, iii) different levels of GMFCS of the study population, and iv) different statistical analyses.

Comparing the simple and multiple regression results further in terms of the importance of trunk control on gait we found only one other study which showed that trunk control (quantified by the "Segmental Assessment of Trunk Control") explained 38-40% variance of the GMFM in 92 children with CP (GMFCS I-V) [16]. In our study, the TCMS explained half of the variance of the mTUG within an ambulant sample (GMFCS I-IV). Although our results confirmed the strong relationship between trunk control and gait capacity, a meaningful clinical interpretation of this finding in terms of causal relation between the two is difficult. This is due to the current

lack of knowledge concerning the responsiveness of the TCMS and the lack of intervention studies which might have included the TMCS. Thereby it is unknown how likely it is to increase a patient's TCMS score and whether this results in an improvement of the mTUG.

Relationship between lower extremity motor functioning and trunk control

Regarding our secondary objective, this is, to our knowledge, the first study investigating the relationship between lower extremity impairments on trunk control in children with CP. Our *a priori* formulated hypotheses were confirmed by Spearman rank correlation coefficients exceeding 0.7 for the MMT and SCALE with TCMS. However, the correlation between MAS and the TCMS was lower than expected. These outcomes seem to support two clinical impressions, formed prior to conducting this study, namely, that patients with better active trunk control (e.g. due to training) or passive trunk control (e.g. supported sitting or brace) have a better capacity for improving selective movements and strengthening of their lower extremities. Furthermore, the strong relationships between the trunk and the lower extremity functioning might be explained by their close neuroanatomical positions on Penfield's homunculus.

We identified only one recent study which addressed a similar topic. Heyrman et al [12] investigated the impact of lower leg kinematics on trunk deviations in children with CP assessed during walking (as opposed to when sitting, as in our study). For measuring lower limb movements they used the Gait Profile Score (GPS). They found no significant correlations between the trunk parameters during gait (i.e. Trunk Profile Score) and the GPS ($r = 0.35$, $p = 0.13$) and only fair correlations between the TCMS and GPS ($r = -0.49$). Furthermore, the correlations between trunk parameters assessed in sitting (TCMS) and during gait were higher ($r = -0.63$ - -0.43). Therefore, they suggested that trunk deviations during walking are not exclusively associated with the presence of lower limb gait impairments and can thus be regarded as a discrete source of impairment and not merely a compensation [12].

Methodological Considerations

As mentioned above, the problem of multicollinearity should be considered when interpreting these results [31]. The correlation matrix revealed high correlations ($\rho > 0.6$) between the MMT vs. SCALE, MMT vs. TCMS, and SCALE vs. TCMS. Furthermore, the average variance inflation factor of the starting model was above "1", which is considered as a threat to the validity of the model [30]. The presence of multicollinearity of the aforementioned variables makes it impossible to obtain unique estimates of the explained variance as these variables account for the similar variance and their beta values are therefore interchangeable (Type II error) [33].

Our regression results showed that when predicting gait capacity by MMT, SCALE, MAS, and TCMS scores, the SCALE and MMT scores were removed from the model as their scores explained a similar amount of variance in mTUG variance as the TCMS. Please note that these results do not indicate that SVMC and leg muscle strength do not influence gait capacity. The MAS, which on its own only correlates weakly with mTUG, seems to explain another part of the variance. Therefore only the MAS and the variable with the highest beta value (TCMS) were kept in the final model.

This interpretation is supported by the results of the simple regression analyses, which showed that SCALE and MMT explained the second and the third largest amount of variance in mTUG (43% and 40%, respectively).

An alternative, if more complex approach to handle multicollinearity is to run a factor analysis (i.e. Structural Equational Modelling [6]) on the highly correlated predictors and to use the resulting factor scores (or latent variable) as a predictor [33]. As this statistical approach requires a larger sample size, it might be considered for future studies investigating similar research questions within a larger sample.

Concerning further methodological limitations about the generalizability of these study results, the dominance of participants with a higher gross motor/walking abilities level (GMFCS I and II = 66.4% versus GMFCS III and IV = 33.6%)) should be considered. This underrepresentation of children with more severe mobility problems might also possibly explain the lower

correlation with the MAS. The scatterplots of the MAS versus TCMS and mTUG reveal the dominance of participants with only a low level of spasticity.

Another limitation is that we did not record the participants' lower limb range of motion, which also can potentially affect a patient's gait capacity. However, previous studies have shown no or weak correlations of this impairment with gait or walking performance [10,11].

Finally, it should be considered that the mTUG is a measure of both gait and balance activities, and thus might require more trunk and motor control than other commonly performed gait capacity tests (e.g.10-meter walking test).

Clinical implications

First the relatively weak correlations between the MAS and gait capacity, as indicated in the current study, showed that spasticity was not the main factor limiting (trunk control or) gait capacity in this sample of children with CP. This interpretation is supported by the previous studies [5,8-11] where spasticity, among other impairments (i.e. muscle weakness, impaired SVMC, contractures, learning difficulties) also did not have the strongest impact on gross motor function in children with CP. These findings as well as a recently increasing number of studies investigating the influence of SVMC on gait development [4] and gross motor function [5-7] challenge the traditionally claimed importance of spasticity management in ambulatory children with CP (GMFCS I-III).

Secondly, our results show, how, trunk control and lower extremity impairments independently and/or in combination may influence gait capacity. In addition we revealed, for the first time, the interrelationship of these two body functions. Based on our findings and those of previous studies investigating either trunk control [12-14,16] or gross motor performance [5,8-11], we cautiously suggest that therapists may wish to address the potential importance of trunk control as well as lower extremity functioning when attempting to improve gait capacity in children with GMFCS I-III.

Conclusion

The results of this study reveal that trunk control as well lower extremity function, both assessed in sitting, are moderate to highly related to gait capacity in children with CP. Using a regression model to predict gait capacity, with lower extremity and trunk functioning as independent variables, we aimed to contribute new insight/knowledge for gait-rehabilitation in children with CP. Despite that the multiple regression models were limited by multicollinearity of some variables, we were able to show, on the one hand, that trunk control, muscle strength, and SVMC account for a similar amount of gait capacity variance. Spasticity, on the other hand, accounts for the remaining but considerably lower amount of mTUG variance. This study provides also the first evidence that lower extremity strength, SVMC, and trunk control are highly correlated. Overall, the results of this study may indicate consideration of a case for combined strength and motor control training of the trunk and the lower extremity for gait-rehabilitation in children with CP (GMFCS I-III).

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Declaration of Interest

None of the funders were involved in the study design, data collection, analysis, and manuscript preparation and publication decisions. All ideas and decisions in relation to this study were made independently by the authors. No potential conflict of interest was reported by the authors. This research project was funded by the "PhysioSwiss" (CH); "Physiotherapy Science Foundation" (CH), "Mäxi-Foundation" (CH) and the "Swiss National Science Foundation (Project 32003B_156646)" (CH).

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Table I: Participants' clinical and functional characteristics

Measures	spastic CP n=52				
	mean	(SD)	median	(IQR)	range
MMT total score *(0-60)*	43.8	(10.8)	44.0	(20)	20 – 60
SCALE total score *(0-20)*	10.8	(4.3)	12.0	(5.2)	0 - 19
MAS total score *(0-48)*	4.0	(3.5)	2.5	(4)	0 - 20
TCMS					
TCMS – static (0-20)	17.1	(4.2)	19.0	(5.2)	4 - 20
TCMS – selective (0-28)	13.2	(6.2)	14.0	(8.2)	1 - 26
TCMS - dynamic (0-10)	7.3	(3.0)	8.0	(4.2)	1 - 10
TMS - total (0-58)	37.5	12.5	41	(14.2)	6 - 56
mTUG (s.)	11.6	(10.6)	7.9	(5.5)	4.3 - 47.5
Age (yy.mm)	11.9	(4.6)	11.7	(7.6)	5.9 - 19.11

Abbreviations: MMT: Manual Muscle Test; *SCALE*: Selective Control Assessment of the Lower Extremity; *MAS*: modified Ashworth Scale; *mTUG*: modified Time Up and Go test; *TCMS*: Trunk Control Measurement Scale, *SD:* Standard Deviation; *IQR:* InterQuartile Range

Table 2: Spearman's correlation coefficients (ρ) between lower extremity impairments, trunk control and gait capacity

spearman`s rank (ρ)	*MMT*	*SCALE*	*MAS*	*mTUG*
MMT (total)	***1.00***	***.849*** *(p<001)*	***-.255*** *(p=.068)*	***-.787*** *(p<.001)*
SCALE (total)	***.849*** *(p<.001)*	***1.00***	***-.435*** *(p=.002)*	***-.685*** *(p<.001))*
MAS (total)	***-.255*** *(p=.068)*	***-.435*** *(p=.002)*	***1.00***	***.356*** *(p=.010)*
TCMS - static	***.711*** *(p<.001)*	***.604*** *(p<.001)*	***-.189*** *(p<.001)*	***-.695*** *(p<.001)*
TCMS - selective	***.665*** *(p<.001)*	***.717*** *(p<.001)*	***-.362*** *(p<.001)*	***-.493*** *(p<.001)*
TCMS - dynamic	***.770*** *(p<.001)*	***.675*** *(p<.001)*	***-.218*** *(p<.001)*	***-.614*** *(p<.001)*
TCMS (total)	***.764*** *(p<.001)*	***.757*** *(p<.001)*	***-.296*** *(p=.033)*	***-.597*** *(p<.001)*
Age				***.093*** *(p=.126)*

Abbreviations: MMT: Manual Muscle Test; *SCALE*: Selective Control Assessment of the Lower Extremity; *MAS:* modified Ashworth Scale; *mTUG:* modified Time Up and Go test; *TCMS:* Trunk Control Measurement Scale

Table 3: Simple and multiple linear regression analysis for predicting gait capacity

Dependent variable	Independent variable	B	Std. Error B	*β*	R^2
mTUG	**simple linear regression**				
	Constant	*36.08*	*4.34*		
	MMT (total score)	-0.56	0.09	-.637 (*p*<.001)	**.40**
	Constant	*28.99*	*3.02*		
	SCALE (total score)	-1.60	0.26	-.657 (*p*<.001)	**.43**
	Constant	*4.93*	*1.87*		
	MAS (total score)	1.67	0.35	.559 (*p*<.001)	**.31**
	Constant	*34.93*	*3.21*		
	TCMS total	-0.62	0.08	-.734 (*p*<.001)	**-.54**
	Constant	11.83	4.32		
	Age	0.04	0.36	-.016 (*p*=.909)	**.00**
	multiple linear regression: *MMT, SCALE*, MAS,TCMS (backward modelling)				
	Step 1				
	Constant	*26.91*	*4.34*		
	SCALE	0.34	0.45	.139 (*p*=.459)	
	MMT	-0.20	0.16	-.226 (*p*=.213)	
	MAS	1.23	0.30	.410 (*p*<.001)	
	TCMS	-0.46	0.11	-.542 (*p*<.001)	**.68**
	Step 2				
	Constant	*28.88*	*3.81*		
	MMT	-0.12	0.12	-.136 (*p*=.306)	
	MAS	1.11	0.26	.371 (*p*<.001)	**.68**
	TCMS	-0.44	0.11	-.520 (*p*<.001)	***(p=.459)***
	Step 3				
	Constant	*26.92*	*3.31*		
	MAS	1.12	0.26	.376 (*p*<.001)	**.67**
	TCMS	-.528	0.07	-.624 (*p*<.001)	***(p=.306)***

Abbreviations: MMT: Manual Muscle Test; *SCALE*: Selective Control Assessment of the Lower Extremity; *MAS*: modified Ashworth Scale; *mTUG*: modified Time Up and Go test; *TCMS:* Trunk Control Measurement Scale; *B:* Beta (unstandardized regression coefficient); *Std. Error B:* standardized error of Beta; *β:* standardized regression coefficient; R^2: coefficient of determination

Figure 1: a) Scatter plots and Spearman's correlation coefficients (ρ) between lower extremity impairments, trunk control and gait capacity; b) Scatter plots and Spearman's correlation coefficients (ρ) between lower extremity impairments and trunk control

Abbreviations: MMT: Manual Muscle Test; *SCALE*: Selective Control Assessment of the Lower Extremity; *MAS*: modified Ashworth Scale; *mTUG*: modified Time Up and Go test; *TCMS*: Trunk Control Measurement Scale

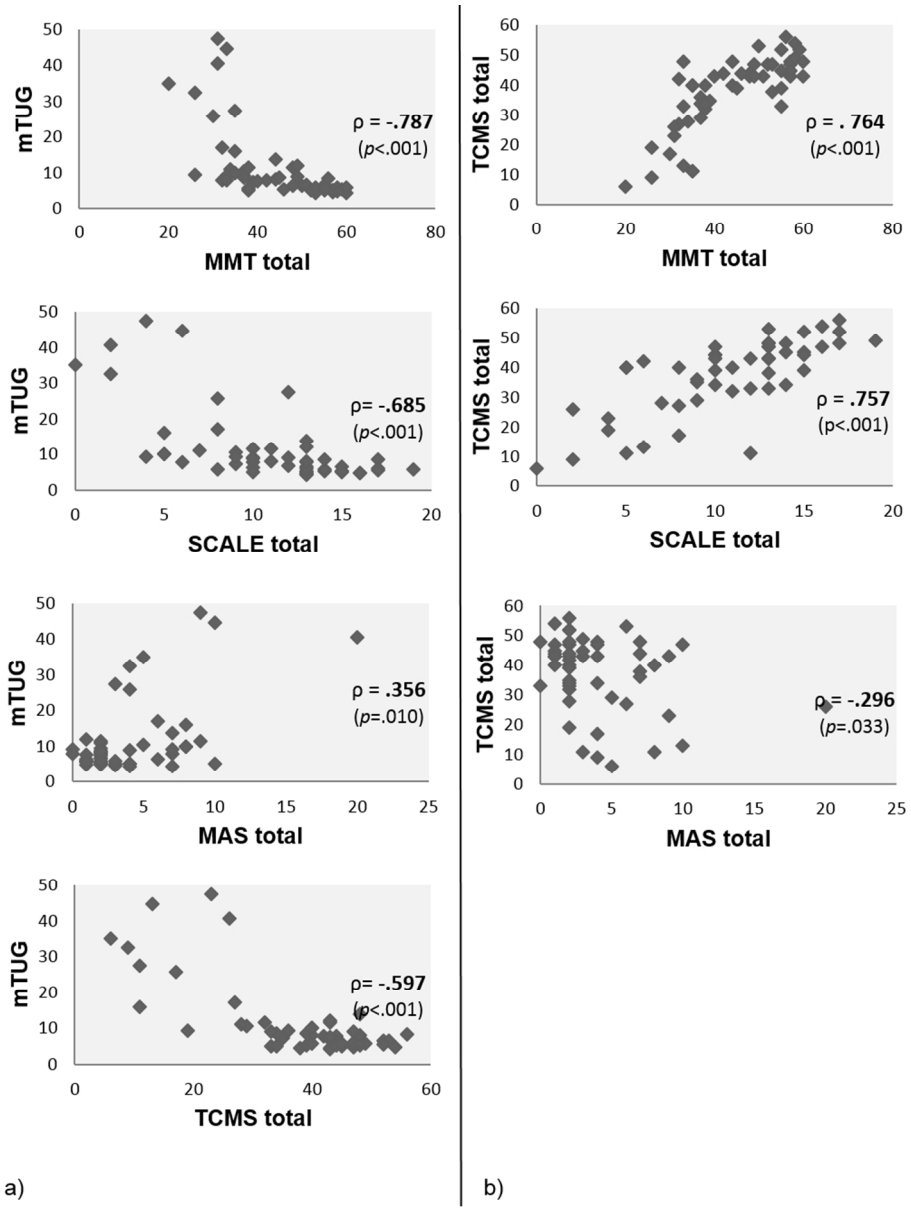

Figure 1: a) Scatter plots and Spearman's correlation coefficients (ρ) between lower extremity impairments, trunk control and gait capacity; b) Scatter plots and Spearman's correlation coefficients (ρ) between lower extremity impairments and trunk control
Abbreviations: MMT: Manual Muscle Test; SCALE: Selective Control Assessment of the Lower Extremity; MAS: modified Ashworth Scale; mTUG: modified Time Up and Go test; TCMS: Trunk Control Measurement Scale

Figure 1
175x224mm (150 x 150 DPI)

IMPLICATIONS FOR REHABILITATION

- Trunk control was the strongest predictor for gait capacity in a regression model with lower extremity spasticity, muscle strength and selectivity and age as independent variables.
- Lower extremity muscle strength, selectivity and trunk control explained a similar amount of gait capacity variance which is higher than that explained by lower extremity spasticity.
- Lower extremity muscle strength and selectivity correlated strongly with trunk control.
- Therefore, we cautiously suggest that a combined trunk control and lower extremity training might be promising for improving gait capacity in children with CP (Gross Motor Function Classification System level I-III), which needed to be tested in future intervention-studies.

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No.	Recommendation	Page No.	Relevant text from manuscript
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2	
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2	
Introduction				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3	
Objectives	3	State specific objectives, including any prespecified hypotheses	4	
Methods				
Study design	4	Present key elements of study design early in the paper	4-5	
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4	
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	4	
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	NA	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-6	
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5-6	
Bias	9	Describe any efforts to address potential sources of bias	NA	
Study size	10	Explain how the study size was arrived at		

Continued on next page

Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6
		(*b*) Describe any methods used to examine subgroups and interactions	NA
		(*c*) Explain how missing data were addressed	7
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	NA
		(*e*) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	7
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7
		(b) Indicate number of participants with missing data for each variable of interest	7
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	NA
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	NA
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	NA
		Cross-sectional study—Report numbers of outcome events or summary measures	NA
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	NA
		(*b*) Report category boundaries when continuous variables were categorized	NA
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA

Continued on next page

Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	8-10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	10-11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11
Generalisability	21	Discuss the generalisability (external validity) of the study results	11-12
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	12

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.